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Student's voices on Science teaching and learning based on Virtual Instrumentations. An international comparative view

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Abstract

The paper "*Students' voices on Science teaching and learning based on Virtual Instrumentations. An international comparative view*" describes results of an empirical study made at the level of different European schools, which offered students in Science lessons the occasion to reflect on the impact of virtual experiments and tools for their learning, motivation and disposition towards this study field. Our research intention was to identify the variables of a virtual instrumentation based Science lesson that makes it effective and attractive for students. Views of students are analyzed in relation with the socio-cultural and educational values that vary in different countries.

Keywords: Virtual instrumentation; virtual experiments; science education.

1. Problem Statement

The present paper is based on a large empirical study made at the level of schools in five different European educational systems (Spanish, Romanian, Polish, Greek and Finish), initiated within the European Comenius project named Virtual Community Collaborating Space for Science Education (VccSSe), a project developed with the financial help of European Commission that had as a main goal the analysis of the effective possibilities of using the virtual instrumentation tools in Science teaching and learning.

The study offered students in Science lessons the occasion to reflect on the impact of virtual experiments and tools for their learning, motivation, on the aspects they liked and on those which did not like in the Science classes based on virtual applications. A comparative analysis of findings is also offered, in relation with the socio-cultural and educational values that vary in different countries. The anchors used in the processing of the data collected from students are partially extracted from a previous thorough analysis of the Science curriculum in the different previously mentioned European countries. Given the balanced distribution of the involved countries across Europe and different European communities (former communist countries, Northern and Southern European countries

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Western European countries) we trust that the data presented here can be regarded as relevant for the European Science teaching and learning in general.

The field of Science education comprises across European curriculum contents related to the following school subjects: Mathematics, Physics, Chemistry, Biology and Geology. In a limited number of cases, such as the case of Spain, Science area includes transversal, integrated school subjects like science, technology and society, a subject aimed to study the social aspect of the science and their impact in the past, in the present, and in the future in our society. All these subjects are included in lower and upper secondary curriculum with different number of teaching hours at different levels.

Science curriculum offer vary in different European educational systems in terms of:

- Contents structure and degree of contents integration
- Types of competences targeted and trained
- Recommended teaching methodologies
- Types of learning experiences to be organized

At the same time European Science curriculum registers a continuing reform that organizes in the present around the series of trends. Thus learning is regarded in curricular documents as an individual and common process of building knowledge and skills. The effective learning must be situational and open new possibilities for participating in social activity. Consequently, it must be focused on competences: ability to sustain abstract reasoning; the development of systems-based thinking, as opposed to a partial and fragmented understanding of phenomena; creativity, curiosity, the ability to think of multiple alternatives to solve a given scientific problem; in other words, the development of diverging thinking. The curriculum is focused on the ability to work in teams, the willingness to seek and accept criticism, and the development of critical thinking. As a result, teaching needs to be focus on evaluating the reliability and importance of knowledge. Instructional mmethodology must support active learning. The different countries Science curriculum commonly mentions a set of similar active methods: problem based learning (mentioned by all countries), project based learning (3 countries), cooperative learning (2 countries), integration of special needs and individual learning habits (2 countries), extending the learning environment towards social factors such as museums, laboratories, medical centers (mentioned by Spain). The tools that foster active participation mentioned are computers, media technology, data networks, and interactive board.

Given this continuously changing educational landscape, the use of virtual instrumentation tools can offer solutions for some of the challenges of Science training. Virtual instrumentation tools can offer new, innovative educational means with potential for supporting the effective teaching.

2. Purpose of Study

Our research intention was to identify the variables of a virtual instrumentation based Science lesson that make it effective and attractive for students. Thus we designed and developed an exploratory study that was occasioned by a number of research actions developed by the partnership of the above mentioned project. Within the VccSSe project, teacher trainers of the five involved countries developed a set of training materials that illustrate the educational use of the following virtual instrumentation software: Cabri Geometry II, Crocodile Clips, Geogebra and Labview.

Consequently, a large number of teachers of Mathematics, Physics, Chemistry and integrated sciences that teach in lower and upper secondary schools were trained in the partnership institutions. As a result of the course, a number of 218 didactic products were designed each of them including a virtual application of different type (demonstration, experiment or exercise) associated with a science lesson plan. Following the classroom implementation of these teaching tools, the students were questioned regarding the impression these lessons created on them. The present study discusses students' answers, aiming on identifying their specificity in relation with students' country of origin and their socio – economical and educational background.

3. Methods

A large number of lower and upper secondary schools students engaged in Science lessons organized around virtual experiments was questioned regarding the aspects they appreciated and aspects they did not like in this type of lesson. Students' views were synthesized according to the opportunities they see for learning through Virtual experiments, the factors that motivate them to attend these lessons and the improvements they see as possible for these type of lessons.

The survey was based on a five items questionnaire that included both open and multiple answers questions. A number of 2798 students were involved in the lessons designed during the courses carried on. Consequently, they had the opportunity to reflect on the impact of virtual experiments and tools for their learning, motivation, on the aspects they liked and on those which did not like in the Science classes based on virtual applications. After the questionnaire protocols were collected we accessed directly the questionnaires obtained from Romanian students. Due to the limitations in information processing given by the fact that all the other questionnaires were expressed in national languages of the project partnership countries, we accessed the reports that the partners other then Romanian provided. They were structured as a quantitative detailed report on the multiple answers questions and a synthetic report of answers to the open questions.

Quantitative and qualitative analysis of the data collected was made in order of offer a comprehensive, comparative image of the students' attitude towards Science lessons organized around virtual experiments, demonstrations and explanations.

4. Findings and Results

A considerable number of students expressed their preference for the use of computers in their classrooms as suitable to their culture and era in contrary to the use of paper and pencil.

In their own words "*The lesson became easier than in the paper and blackboard environment; when using computers, low grade students understood the lesson' (*Greek student*)* or '*The application conducts activities at your own pace and that happens at the time you choose and safely' (*Finish student*)*. Some students also expressed their preference for group working that is implied by the interactive use of virtual experiments, or, more general, for the work atmosphere created by the presence and use of computers.

Students' answers prove that they associate the use of computer and specialized software with modern, contemporary teaching. They are generally motivated for this teaching approach and their general computer skills help them make good use of software applications' learning tools.

A great number of students appreciate the opportunity of *interacting with the virtual experimental space*. Specifically they mentioned the following tools for manipulation of the learning environment: drawing, manipulation of variables, experimenting and understanding of abstract concepts, by integrated a large number of concrete examples and contextualized situations.

Students reported that they were attracted by the possibility to draw colorful shapes using the tools of the software application, particularly in case of Cabri Geometry II and Geogebra. In fact, this possibility helped them become interested and focused during the specific lesson and to experiment with otherwise complicated to draw complex figures. They found easier to carry on specific learning and exercising tasks such as drawing geometrical figures more precisely, accurate measuring of the geometrical components.

The respondents were impressed by the possibility of dynamic experimentation with geometrical shapes (with Cabri Geometry, by using the 'drag mode' operation) or with changing variables involved (in case of Crocodile Clips, LabVIEW or Geogebra). Students realized that, using this operation, they have the ability for easy and fast creation of multi-forms of shapes and situations, while at the same time conserving their properties. They came to understand the dynamic transformation of shapes as motion of shapes and to deducing the determination relationships between components of an experimental situation. In fact, students came to see dragging or changing variables as a dynamic (fast and easy) transformation of geometrical shapes or spaces and the correspondent measurements: '*we can observe and study many forms of the same geometrical construction simultaneously*' (Greek student); '*you can change the data of the experiment as you feel*' (Spanish student).

An important number of students also expressed that they could acquire better and understand faster and easier the concepts in the case of dynamically experimenting in a safe mode with physical, chemical or geometrical spaces. Students expressed that '*Some difficult topics for the typical paper and blackboard environment became more easy and understandable by the use of technology' (Greek student)*. Other students also commented that '*we became active and quickly understood the topics in question*' (Greek student), or that '*It is easier to understand the concepts and experiments with the computer helps us a lot*' (Spanish student), '*Helped me to better use my imagination for understanding and exploring Physics concepts*' (Romanian student), '*It is easy to explore the effects, the influences,* *the changes and effects*' (Finish student), '*Manipulating the aircraft: capacitors, diodes, transformers. Not only do you see represented on the board and in the book and you have to imagine that happening*' (Spanish student), '*easier than learning by reading a book'* (Finish student).

An important number of students referred to the support in learning given by the intuitive aspect of the virtual learning environment. Students expressed that everything was helpful when they used VT&E. Specifically; they realized that the use of visual images was very helpful for them to easily understand the concepts in question. In addition, they expressed that the tools provided by the software helped them to easily use rules or theory, to automatically perform some specific geometrical or physical constructions ('*from the library of tools'*) and measurements as well as automatic tabulation of numerical data. Finally, some students emphasized the diversity of tools provided as helpful to construct, elaborate or observe a plethora of demonstrations, problems of experiments.

Some students expressed their answers with the reference of the feelings and attitudes that the virtual instruments based lessons provide. The lessons made them feel pleasant, focused, interested and active. The aspect of novelty that these lessons include must be regarded as a motivational factor here. Yet, even in the case of repetitive lessons that use virtual experiments the motivation is preserved, through the novelty of the various virtual environments that may be created.

A large number of general comments were also offered. Students characterized the way of teaching by using of Cabri in their school practices as: 'It is audacious and modern to school practices', '*it is good, visual, interesting and special*' (Greek student), '*attractive through various colours and shapes one may create'* (Romanian student) '*this method of teaching is fast, interesting, direct, effective, easy to use and easy to understand'*(Greek student), '*you may perform difficult chemistry experiments safely and cheaply*' (Romanian student). Some of the students have seen the experiment as a regular activity in the classroom and not as a very new thing (in case of Spanish students). Contact with VI is thus, as natural as with any other technological item. A great number of students felt more involved in lessons, with consequences in improved *intrinsic motivation* (mentioned by Polish students).

A minority of the students experienced some difficulties in using and learning to use the software. They noted that drawing or manipulation of variables was time consuming. They alos remarked that in some cases there was no help from the teacher during the use of the software and its complexity and difference from traditional means and instruments made it hard to learn how to use. A few students also commented that the conditions under which the experiments where carried out were less than satisfactory, namely, there were too many students for the computers available (case of Greek, Romanian, Polish and some of Spanish students), it was dark or noisy in the room (Romanian and Spanish students); the experiments were not very well organized in terms of facilities (Greek and Finish students) or lesson management (Polish students). Different students mentioned the fact that the time of computer use was not enough or that the classes were too short. Very few students expressed the precise preference for the traditional exploration of science concepts.

Without exception in all groups of students the majority appreciated that the virtual experiments helped them to understand the science concepts and expressed their wish for more lessons of this type in a regular (over 75% of respondents) or occasional manner (10 to 25% of students).

Many of the students remarked that they would like to participate in more lessons where virtual tools and experiments will be used, in their daily lives. If possible, they would like this method to be used in all subjects and a variety of science topics, with more attractive and diverse layouts. A very few number of students mentioned that they would like to have the possibility of extending their exploration of Science knowledge through virtual applications software at home. This would imply the creation at the level of school of a library of experiments which may be accessed at will by all the students.

5. Conclusions

We appreciate that the project offered the occasion of experimenting with new and innovative pedagogical tools for optimizing the teaching and learning of Science subjects, topics that usually put problems to ordinary students. Apart from a motivational force and a more interactive learning atmosphere, the use of virtual tools and experiments in the classroom helps imagining abstract processes, brings concepts into applicative, concrete concepts, favor cooperation, manipulation of reality and formulation of conclusions through own cognitive efforts.

Generalizing from students' opinions presented here, we can deduce a set of criteria for effective design of virtual experiments and tools Science lessons. These learning situations should be formative for both students and teachers, by improving students' understanding of science contents and their learning motivation, by supporting their correct application of knowledge. At the same time virtual experiments and tools based effective lessons have the potential to increase teachers' science didactics awareness, improve teachers' understanding regarding students' learning and motivation and challenges teacher to improve his teaching behaviour.

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